Moored pCO_2 Program

C.L. Sabine (PMEL), F. Chavez (MBARI), R.A. Feely (PMEL),
S. Maenner (PMEL) and G. Friederich (MBARI)

Goal: Evaluate the temporal variability in air-sea CO_2 fluxes by conducting high resolution time-series measurements of atmospheric boundary layer and surface ocean CO_2 partial pressure (pCO_2).

Approach: Develop an inexpensive, robust, accurate pCO_2 system that can be deployed on a variety of buoy configurations for up to a year at a time throughout the global oceans.

Advantages of MBARI/PMEL pCO_2 System

Proven Technology

This system relies on a proven high precision, robust technology utilizing the LiCor 820, a single path, dual wavelength infrared gas analyzer. With this detector, the system is able to measure absolute concentrations of air and surface seawater pCO_2.

Traceable Standards

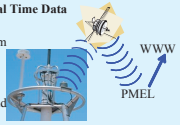
In 2003, PMEL added the capability of calibrating the system in the field using a two point calibration. The system uses a soda lime chamber to generate a zero reference and small cylinder of a high CO_2 gas traceable to WMO standards through the Climate Monitoring and Diagnostics Laboratory (CMDL).

Low Power

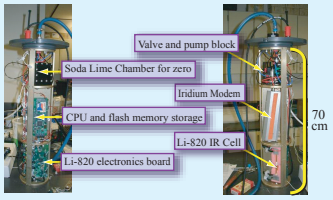
The system is very low power and can be operated for over one year with a modest battery pack consisting of ~100 alkaline D-cells batteries. Components can be put into "sleep mode" when not collecting samples.

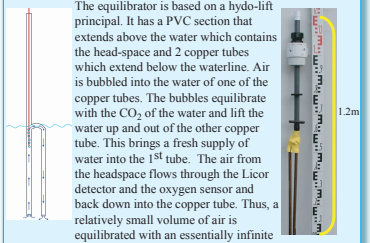
Near Real Time Data

Once per day, the buoy data is sent back to PMEL via an Iridium satellite. The data include the measured values and a range of diagnostic values that inform us of the operation of the system and data quality. Data are posted in near real time to the web.



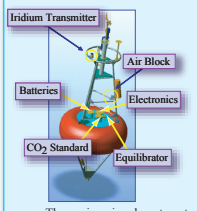
The Electronics Package is Based on an MBARI Prototype Developed for Drifting Buoys





The equilibrator is based on a hydo-lift principal. It has a PVC section that extends above the water which contains the head-space and 2 copper tubes which extend below the waterline. Air is bubbled into the water of one of the copper tubes. The bubbles equilibrate with the CO_2 of the water and lift the water up and out of the other copper tube. This brings a fresh supply of water into the 1st tube. The air from the headspace flows through the Licor detector and the oxygen sensor and back down into the copper tube. Thus, a relatively small volume of air is equilibrated with an essentially infinite volume of water.

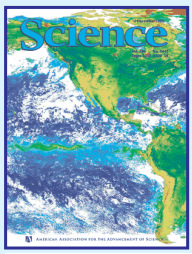
pCO_2 System Can be Deployed on a Variety of Buoy Designs



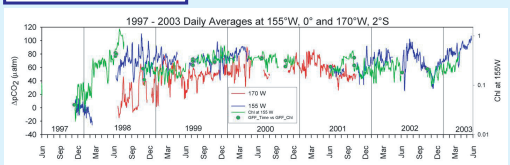
The engineering department at PMEL modified the basic TAO Atlas buoy design to accommodate the pCO_2 system.

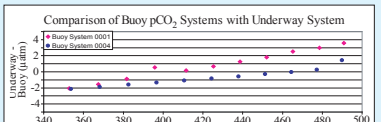
In August, as part of the of the Multi-disciplinary Ocean Sensors for Environmental Analyses and Networks (MOSEAN) project, PMEL will deploy a pCO_2 system on the HALE-ALOHA mooring at the Hawaii Ocean Time-series (HOT) site.

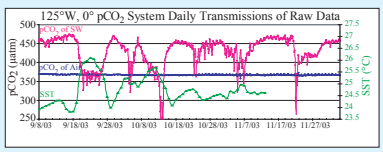
Achievements: In close collaboration with the PMEL TAO group, we have been able to monitor the air-sea pCO_2 difference in the equatorial Pacific since 1997. Expansion of the array to 4 TAO buoys in 2003 has allowed us to better characterize the temporal dynamics of this critical ocean region for CO_2.



The MBARI design pCO_2 system and equilibrator has proven to be reliable and accurate over extended deployments. The data from the 155°W and 170°W moorings (shown below) are among the longest moored open ocean pCO_2 records in existence. Gaps in the data are primarily from vandalism or other mechanical failures. The moored pCO_2 record helped characterize the pCO_2 dynamics from the 1997-98 El Niño as described in a 1999 Science article (shown on left).



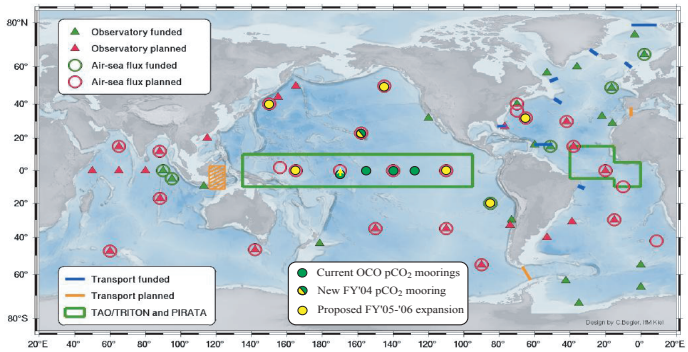




In 2003, MBARI transferred the pCO_2 system technology to PMEL to allow us to take the lead in developing the moored ocean observing array. The new MBARI/PMEL systems utilize a new less expensive LiCor detector that allows direct measurements of air and surface water pCO_2 concentrations instead of just the air-sea difference (see description above). The new systems have been extensively compared to our standard underway pCO_2 systems and appear to be accurate to within a few µatm (see figure to left). We are continuing to refine the systems and hope to soon achieve 1 µatm accuracy.

The first two systems were deployed at 125°W, 0° and 140°W, 0° in September 2003. The daily satellite transmissions (see figure to left) show large temporal variations in the sea surface pCO_2 that correlate well with the passage of tropical instability waves.

Future Directions: Over the next two years our goal is to expand the array to constrain the nature of the El Niño CO_2 signal in the equatorial Pacific and investigate the teleconnections of this variability into the North Pacific. Our expansion will focus on the GEO reference flux sites to take advantage of the additional supporting measurements available at these locations.



http://www.pmel.noaa.gov/co2/moorings